CATALYTIC DIFFERENTIAL CALORIMETRIC GAS SENSOR

This is a divisional of application Ser. No. 08/311,299, filed on Sep. 23, 1994 now U.S. Pat. No. 5,707,148.

TECHNICAL FIELD

The present invention is concerned with diagnostic methods and devices for monitoring exhaust gases generated from automotive engines.

BACKGROUND OF THE INVENTION

The Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) have implemented stringent diagnostic requirements for automotive emissions. As part of their requirements, CARB has mandated on-board monitoring of the exhaust gas conversion efficiency of catalytic converters, under its On-Board Diagnostics phase 2 (OBD-II) plan.

Exhaust gas constituents (EGC) sensors have been proposed as an answer to the new regulation. One such potential EGC sensor is the catalytic calorimetric sensor.

In a catalytic calorimetric sensor combustible gases (such as hydrocarbons HC, carbon monoxide CO, hydrogen H_2, etc.) are oxidized with the help of a catalytic layer. The generated heat, measured as the increase in substrate temperature, results in an electrical output signal proportional to the amount of combustible gases present in the gas mixture.

Catalytic calorimetric gas sensors typically operate in the 250° to 500° C. temperature range, making them in principle applicable for automotive applications. Although generally of lower sensitivity than semiconducting-type gas sensors, catalytic calorimetric sensors appear to be considerably more stable and faster responding. However, existing catalytic calorimetric sensors have been investigated and found not suitable for automotive use because of application-oriented limitations. Such limitations have included a lack of sensitivity, restrictive detection limits and response time, susceptibility to flow and temperature variation.

These disadvantages of the prior art devices combine to limit the usefulness and applicability of catalytic calorimetric gas sensors.

U.S. Pat. No. 4,355,056 discloses a method of manufacturing a differential thermocouple combustible sensor which makes the sensor relatively insensitive to sulfur poisoning. The catalytic thermocouple junction of a catalytic/non-catalytic junction pair is formed by coating it with a gel to increase the surface area and then with a chloroplatinic acid solution to make it catalytic. The catalytic junction is then treated with H_2S to achieve a high catalyst surface area. In this patent, the noble metal catalyst is applied from a solution, which results in large particle sizes and an accordingly small number of catalytic sites, the resulting sensor lacks sensitivity.

The prior art suffers from a lack of sensitivity. There thus exists a need for a more sensitive gas sensor which also exhibits durability.

SUMMARY OF THE INVENTION

The present invention relates to a sensitivity-enhanced catalytic calorimetric sensor.

The present invention discloses a catalytic calorimetric sensor comprising: a substrate, a temperature measuring layer and a sol-gel processed catalytic layer.

The invention also discloses a catalytic calorimetric sensor comprising: a substrate, a temperature measuring layer and a catalytic layer which comprises a sol-gel processed washcoat and a plurality of catalytically active metal particles loaded thereon.

An alternative embodiment of the present invention teaches a catalytic calorimetric gas sensor, comprising: a substrate, a temperature measuring layer and a catalytic layer which comprises a sol-gel processed washcoat and a plurality of sol-gel processed catalytically active metal particles deposited on the washcoat.

The present invention also discloses a silicon micromachining method for producing a catalytic calorimetric gas sensor to yield a highly reproducible and sensitive combustible gas sensor.

Lastly, the present invention discloses a method to maximize deposition of the catalytically active metal particles in the pores of the washcoat. This method reduces agglomeration of the metal particles while making high surface area metal particles available for catalytic reactions.

Sol-gel processed alumina/silica washcoats are beneficial for use with sensors due to the high surface area and controlled porosity that can be achieved.

The use of a sol-gel processed catalytically active metal particles results in a catalyst comprising smaller metal particles of better uniformity than those provided from conventional coating systems, such as sputtering and the like.

It is an object of the present invention to provide a catalytic calorimetric gas sensor, where some or all of the catalytic layer is processed using a sol-gel technique to create a sensor having an increased number of active catalytic sites for catalytic oxidation of the combustible gas molecules.

It is also an object of the present invention to provide a sensitivity-enhanced calorimetric gas sensor using a sol-gel technique to process some or all of the catalytic layer.

It is another object of the present invention to provide a catalytic calorimetric gas sensor that is more durable and more easy to manufacture.

It is a further object of the present invention to provide a method for fabricating catalytic calorimetric sensors with lower power consumption at potentially lower manufacturing costs using silicon micromachining.

The above objects and other objects, features and advantages of the present invention are readily apparent from the detailed description of the best mode for carrying out the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a schematic representation of the catalytic calorimetric sensor utilized in the present invention;

FIG. **2** is a perspective view of the microcalorimeter design used in the invention herein described; and

FIG. **3** is a cross-section of FIG. **2** taken along lines **4**—**4**.

BEST MODE FOR CARRYING OUT THE INVENTION

The present invention generally relates to the application of a sol-gel processed, high-surface area alumina and/or silica washcoat and catalytically active metals impregnated thereon to fabricate the catalytic layer of a combustible gas sensor. Sol-gel processed alumina-silica materials are ben-